2339

Dup

1651/2111

AN ESSAY ON *THE COMPARATIVE ADVANTAGES* OF VERTICAL AND HORIZONTAL WIND-MILLS:

CONTAINING
A DESCRIPTION OF AN
HORIZONTAL WIND-MILL AND WATER-MILL,
UPON A NEW CONSTRUCTION;
AND EXPLAINING
THE MANNER OF APPLYING THE SAME PRINCIPLE TO
PUMPS, SLUICES, METHODS FOR MOVING BOATS
OR VESSELS, &c. &c.

WITH PLATES.

By ROBERT BEATSON, Esq. F.R.S.E.
Honorary Member of the Board of Agriculture, Member of the Society of London for the Encouragement of Arts, Manufactures and Commerce, and of the Royal Highland Society of Scotland, and late of his Majesty's Corps of Royal Engineers.

LONDON:
PRINTED FOR MESSRS. I. AND J. TAYLOR, HOLBORN; G. G. AND J. ROBINSON, PATERNOSTER-ROW; RICHARDSON, ROYAL EXCHANGE; MURRAY AND HIGHLEY, FLEET-STREET; J. WRIGHT, PICCADILLY; E. NEWBERY, CORNER OF ST. PAUL'S CHURCH-YARD: P. HILL, EDINBURGH; R. CRUTWELL, BATH; AND SOLD BY ALL OTHER BOOKSELLERS IN TOWN AND COUNTRY.
1798.

BRITISH LIBRARY

CONTENTS.

I. On the Powers usually applied to Machinery.

General Remark on Water—Dams—Floods—Water-Mills Situation—Objections—Wind—Wind-Mills—Animal Power—Steam—its great Force—Manual Power. Page 1.

II. On Common Wind-Mills.

Power of the Wind easily obtained—Objections—Uncertainty—Unsteadiness—these Objections answered—great Utility of Wind-Mills—exemplified in Holland—in England—Lincolnshire—Cambridgeshire, &c.—Their Importance in the West India Islands—Improvements on Wind-Mills—Motion of the Sails—Axiom in Mechanics—Lateral Pressure—Power. p. 5.

III. On Horizontal Wind-Mills.

Direct Pressure of the Wind—Necessary Properties of such Mills—often attempted, but on Plans too expensive—Used in Tartary—Asia—Africa—Spain—Method practiced in those Countries to bring back the Vanes against the Wind. p. 10.

IV. Objections to Horizontal Wind-Mills.

Making the Sails return against the Wind, the principal Objection—the late Mr. Smeaton's Opinion of Horizontal Wind-Mills—proved to be erroneous—Demonstration in different ways—may be made more powerful than the Vertical Mill. p. 12.

V. On getting back the Sails against the Wind.

Mr. Smeaton estimates the Disadvantage of getting back the Sails to take away more than half the Power of the Mill—proved in one case, to take away only 1-52d part, and that it may be made even less—that Disadvantage not equal to the Friction in the Common Wind-Mill. p. 18.

VI. Another Objection to Horizontal Wind-Mills answered.

Velocity of the common Wind-Mill sometimes greater than the Wind—this property not peculiar to the Vertical Wind-Mill—other Mills or Wheels may move with greater Velocity than the Power that moves them—exemplified—Horizontal Mills will do the same—demonstrated. p. 26.

VII. Description of Beatson's Royal Patent Horizontal Wind-Mill.

Principles upon which that Mill is founded—Construction of the Parts forming the horizontal Movement—the upper and lower Arms—vertical Shaft—Vanes—Flaps—resisting and non-resisting Sides—Construction on a large Scale. p. 33.

VIII. On the Power of the Royal Patent Horizontal Wind-Mill.

The Power acting on the one Side, great—the Resistance on the other, small—Calculation of the Power—Power may be increased by moving out the Vanes, or diminished by drawing them in—or by opening the Flaps in some of the Pannels of large Mills. p. 40.

IX. On the Uses to which the Patent Horizontal Wind-Mill may be applied.

Grinding all sorts of Grain—Thrashing Mill—Chaff Cutter—Raising Water for all purposes—Manufactories, Distilleries, Breweries—Sugar Mills, &c.—exemplified in nineteen different ways. p. 46.

X. Advantages of the Patent Horizontal Wind-Mill.

Little Expence—no Attendance to turn them to the Wind—will go with any Wind—constructed in any form of Building—easily regulated or stopped—little Friction, and easily kept in Repair. p. 51.

XI. Application of the same Principle to Water-Mills.

Horizontal Water-Wheel—Construction—turns always the same Way, whether the Current runs up or down—a more powerful Wheel of the same sort—Sluices to open and shut themselves—Uses of these Mills—Tide-Mills. p. 53.

XII. Application of the same Principle to other purposes.

Square Pumps—their Construction—Flap Piston—Flap Valve—their Uses on board of Ship in case of a Leak, or Fire—to empty Ditches—Ponds, &c.—Sluices—moving Boats or Vessels—Accelerators—Methods of working them—Conclusion. p. 56.

PREFACE.

MANY doubts being entertained concerning the power of Horizontal Wind-mills, and some eminent mechanics having asserted the impossibility of giving such mills a power equal to Vertical Wind-mills, it is hoped the following Essay will tend to remove all doubts upon that subject, and prove that Horizontal Wind-mills may be constructed equal in power to any other Mills whatever.

The Author is well aware that an idea so very different from what has hitherto generally prevailed, will at first meet with many opponents, perhaps, even with ridicule; but when it is considered that the prejudices formed by some people against Horizontal Mills, have been founded merely on conjecture, or on the effect of such imperfect machines as they have seen tried, and that, in fact no accurate experiments have ever yet been made that could correctly ascertain the power of an Horizontal Mill, properly constructed, it is hoped that the unprejudiced, and those who wish to be informed, will suspend their judgments till they peruse the arguments and calculations in the following pages.

The Author has endeavoured as much as possible to avoid all abstruse calculation, and to convey his ideas in as plain and familiar a style as the subject would admit of. He therefore trusts, that every thing he has advanced will be completely intelligible, and that it will be perused with candour and impartiality.

It was his first intention merely to have given a short description of an Horizontal Wind-mill, on a new construction; but finding he could not altogether convey a sufficient explanation of its principles and power, without entering more largely into the subject; and that it was also necessary to take a cursory view of the principal objections that have hitherto been held forth against Horizontal Wind-mills; he has therefore adopted the following arrangement:

In the first place, he has made a few general remarks on the powers usually applied to machinery, and drawn a comparison between the different kinds in common use.

The utility and advantage of Wind-mills in general are then pointed out, not only in respect to the benefits derived from them in many parts of this kingdom, but also in the West India colonies, and in other countries.

He then proceeds to show the great advantages that would result from a proper construction of Horizontal Wind-mills, particularly by their requiring much less machinery than the common Wind-mill, by their going with any wind, and revolving the same way from whatever quarter it blows (and therefore requiring no attendance to turn them to the wind), by their being easily constructed in any form of building, and thereby affording a great deal more accommodation, and by several other peculiar properties not possessed by the common Wind-mill.

He then explains and illustrates, by different simple and easy calculations, the possibility of constructing such Mills in a manner even more powerful than the Vertical Mill.

In the course of these inquiries, he has stated and examined the opinion of the late Mr. Smeaton upon the subject of Horizontal Wind-mills, and has pointed out and demonstrated wherein that celebrated engineer and mechanic has grossly mistaken and misrepresented the power capable of being given to such mills, by considering the effect of the Wind acting on a plane at right angles to it, and moving before it like the sail of a boat, the same as when acting on a vane moving round upon a centre, which is totally a different case.

The manner of constructing Horizontal Wind-mills on an improved principle is then fully described, after which are shown different ways of applying the same principle to the construction of Water-mills, Pumps, Sluices, methods for moving boats or vessels, and a variety of other useful purposes.

It is universally admitted that no new plan or project whatever can be proposed, however evident its advantages to the community may appear, but will meet with opponents somewhere. The Author therefore does not presume to expect that the plans proposed in the following Essay, some of which are of a very new and uncommon kind, will pass without objections being started against them. He hopes, however, for a fair and candid trial, and trusts to the liberality of the disinterested to judge of the plans he proposes, from the principles upon which they are founded. These are so plain and so simple, and so easily understood without the least knowledge of mechanics, that even those of the meanest capacity may at once pronounce their judgment upon them. For the main and fundamental principle upon which the whole are grounded, rests entirely on the solution of this very simple question: Whether does the wind, or any other fluid, act with most power on a close covered frame, as ABCD, fig. III. or on a similar frame DEFC, that is not covered? If any man will insist on it, and prove that they will act with as much power on the one as on the other, the Author will then freely confess that he has committed a gross mistake, and founded his conclusions upon erroneous principles; but, if it is admitted, and impossible to be controverted, that fluids must and do act with much more power on a covered frame than on an uncovered one, his principles will then hold good, and the plans he proposes, founded on these principles, when executed in a proper manner, must succeed. But it has often happened, that even the best concerted plans have failed, by being improperly executed. In order, therefore, to prevent this as much as possible in the present case, and at the same time (which it is presumed will not be thought unreasonable) to indemnify himself for the great expence and trouble he has been at, the Author has followed the advice of some of his very particular friends, by taking out a Patent for these inventions; a measure which he trusts will be approved, more especially when it is considered that it may be the means of rendering them more useful to the public than they otherwise might have been.

For as the Patentee will give every necessary instruction to those he authorizes or appoints to execute his inventions, it is natural to suppose they will on that account be more perfectly and completely executed than by any others, who may pretend to construct them at a cheaper rate, without his authority and instructions.

A striking instance of this kind happened several years ago, with respect to the Rotherham Plough. When that plough was first introduced, the inventor of it obtained a Patent for it. During the term of his Patent, when the making and vending of it were confined entirely to himself, and to those he appointed, the ploughs performed their work most admirably well, and gave general satisfaction.

When the term of his Patent expired, and every country carpenter was at liberty to make them, they *degenerated* so rapidly that for a long time they were almost totally laid aside; and got even into disrepute, till within these few years that some ingenious mechanics have restored their character.

The Author therefore hopes, that no encouragement will be given to any tradesmen or others, who may attempt, in defiance of the law, to construct his machines without his authority and instructions. For although they are extremely simple in their principle, yet there are some particular instructions necessary to be attended to in the execution, which if neglected might afterwards occasion a good deal of expence and trouble; but if executed in a proper manner, he flatters himself they will give general satisfaction, and prove useful in many respects to the public at large.

ESSAY, &c.

I.

ON THE POWERS USUALLY APPLIED TO MACHINERY.

General Remark on Water—Dams—Floods—Water-Mills—Situation—Objections—Wind—Wind-Mills—Animal Power—Steam—its great Force—Manual Power.

WHERE the situation will admit of a proper fall of water, in sufficient quantity at all times, it is no doubt the best power that can be applied to machinery for most purposes. Such situations are however rarely to be met with, in places where they are most wanted; and, in general, where they are to be found, the great expence of erecting dams, and keeping them in repair; and the risk of having those dams carried away by sudden floods (as is often the case when imperfectly and injudiciously constructed), are objections against water-mills, that require some consideration before such works are engaged in. It often happens too, from the lowness of the situation where water-mills are necessarily obliged to be placed, that the access to and from them is so difficult and so steep, that much inconvenience arises on that account, as well as from the dampness generally found in such low situations.

These objections to water-mills (which however are by no means applicable to water-mills in general), have induced many people to give the preference to wind-mills, and to erect them even on the banks of some rivers, where water-mills might have been constructed very near the same place.

The power of the wind, from the facility of its application, and being obtained without any expence, is perhaps more generally applied to mills, than any other power whatever. It may therefore, with some degree of justice, be considered as the most useful power that is known; especially since the late improvements that have been made on wind-mills, which have rendered it still the more valuable; for there is no sort of work that can be performed by mills, but a well-constructed wind-mill, may be applied to, if placed in a proper situation for the wind to act upon it, in a free and uninterrupted manner.

Next to wind and water, animal power is perhaps the most in use: but this also is liable to several objections; being attended with considerable expence, not only in the erection of a proper building to afford cover to the animals while at work, and in the construction of that part of the machinery by which they communicate motion to the rest; but likewise in the expence of their first purchase, and in their constant maintenance afterwards. Besides, by employing horses or cattle in turning mills, they are either prevented being employed in some other useful and perhaps more profitable work, or in all probability the owner is obliged, on that account, to keep a larger establishment than he would otherwise have occasion to do. The risk of accidents too, which may render them incapable of work, or altogether useless, is another objection against employing animal power, if it can be avoided; for where a certain number is necessary, and only that number is kept; if any one of them is rendered unserviceable, the remainder must stand idle, or at least that work cannot go on without some other assistance.

The power of Steam, is a most useful and most formidable power; and where the work is of that magnitude and importance to afford the expence of erecting and working a steam engine, it is perhaps (if a sufficient quantity and fall of water cannot be obtained), the best and most effectual power that can possibly be used for such a work. But the enormous expence of a steam engine, with all its necessary appendages, both in the first construction, as well as in fuel and attendance afterwards, is so great, that none except very large and valuable works can afford to erect them. Besides these objections, may be considered the great difficulty of keeping them in proper order, and of getting them repaired, in case any part should fail or give way; which must often happen, from the variety of movements, and the prodigious force acting upon them, especially in large engines. The steam engine, therefore, exclusive of its original cost, requires not only a great expence of fuel to keep it going, and proper persons to attend it, but it would require also a good smith, or mechanic, who perfectly understands the construction of all its different parts, to be almost constantly on the spot while it is at work; otherwise much inconvenience and great delays will often happen.

Manual Power is frequently used for small works; but this can either be of so short a continuance, or else there must be so frequent a change of hands, that unless in very trifling works indeed, it never can be of much utility; nor is it to be expected that manual power can, with the least degree of advantage, be applied to give motion to mills or machines that are required to perform any considerable quantity of work.

II.

ON COMMON WIND-MILLS.

Power of the Wind easily obtained—Objections—Uncertainty — Unsteadiness — these Objections answered—Great Utility of Wind-Mills—exemplified in Holland—in England—Lincolnshire—Cambridgeshire, &c.—Their Importance in the West India Islands—Improvements on Wind-Mills—Motion of the Sails—Axiom in Mechanics—Lateral Pressure—Power.

From the above general view of the powers usually applied to machinery, it is clear, that the power of the wind may be obtained with less difficulty and at less expence than any other power whatever. In fact, it may be obtained at no expence at all; for it requires only proper machines or mills to receive its impulse. The only objections against wind, are its uncertainty and unsteadiness. With regard to the first, it may unquestionably so happen at certain times, that there is so little wind as will not move a wind-mill. It will however be observed that such times, when they do happen, are of so short a duration, and bear so very small a proportion to the times during which there is a sufficient quantity of wind for that purpose, that if these opportunities are taken when at command, there are few works but may by that means be carried on without any loss or inconvenience; more especially if the mills are so constructed, that they will go without any attendance, and in all winds; which for many purposes they may easily be made to do, particularly for draining, or raising water. This objection therefore, which is certainly the most material one against Wind, will, in some measure, be counterbalanced by the advantage of its being obtained at no expence or risk, and requiring none to uphold it, as in the case of water, animal power, or steam. Moreover, for many purposes, the mill may be so constructed as to be assisted by animal power, when there is too little wind; which will in some degree obviate that inconvenience.

With respect to the second objection against wind, its unsteadiness or irregularity; that may in a very great degree be corrected by the construction of the mill; for by different contrivances, a well constructed mill may be so regulated, or made to regulate itself in such a manner, as to prevent its going beyond a certain velocity, however violent the wind may blow. When a mill is so constructed, little or no inconvenience can ever arise from the unsteadiness of the wind. When these two objections are properly guarded against, wind-mills may be considered as the most generally useful of all other mills. Indeed their great utility is so well known, that a particular detail of their advantages is quite unnecessary. In some countries, they are almost the only mills in use for all manner of purposes, particularly in Holland; where they are not only used for grinding all sorts of grain, making pearl barley, sawing timber, raising water, but for every other purpose to which mills in general can be applied. In England, too, their advantages are very generally felt.—The very existence of the people in some parts greatly depends upon them, not only for a supply of flour for bread, but by keeping a great extent of country, as in Lincolnshire, Cambridgeshire, &c. from being constantly overflown with water, by which means the finest crops of grain, and the richest meadows and pastures, are obtained, where, were it not for these mills, nothing but stagnant water, or rushes and reeds would be seen. In many other countries wind-mills are of the greatest service; and in the West India islands they are of so much importance, that without them many of our valuable islands could neither manufacture or export so great a quantity of sugar and rum, as they now do by means of their assistance.

Wind-mills being of such general utility, any material improvement upon them must of course be of the same general advantage. Several improvements have already, within these few years, been made upon them: such as making them turn themselves to the wind without any assistance; constructing the sails so as to be furled or unfurled while the mill is going; and some have been constructed to furl and unfurl the sails, and in other respects to regulate themselves, according to the velocity of the wind. These are certainly great improvements, but they are attended with considerable expence; and still there is room for more to be done, in order to remedy the principal objections to the common wind-mill.

To those who have observed the manner in which the common wind-mills act, it naturally occurs, that as the motion of the sails is in general nearly at right angles to the direction of the wind, or, in other words, as the sails move across the wind, a great deal of its power and effect must in consequence be lost; for it is an axiom in mechanics, that the alteration of motion by any external force, is always in the same direction as the right line in which that force acts; and therefore it is clear, that the wind acting upon the sail of a wind-mill, must have a much greater tendency to move it forwards in the same line of direction itself is moving, than in any other direction whatever. But from the manner the sails are fixed and secured, they are prevented moving in the direction of the wind; and were they placed with their surfaces in the same plane with each other, they would not move at all; but being placed in an oblique position to the arms, and to each other, the power of the wind acts upon them in a lateral manner; and by that lateral pressure only gives motion to the sails: consequently, when the lateral pressure is sufficient to overcome the friction of the different parts, the common wind-mill will move with a power, not equal to the power of the wind acting upon the whole surface of the sail, but equal only to the lateral pressure deducting the friction; which pressure will be in proportion to the velocity of the wind, and its power in proportion to the length of the arms of the wind-mill.

III.

ON HORIZONTAL WIND-MILLS.

Direct Pressure of the Wind—Necessary Properties of such Mills—often attempted, but on Plans too expensive—Used in Tartary—Asia—Africa—Spain—Method practised in those Countries to bring back the Vanes against the Wind.

When we consider the surprising effects of the wind upon the common wind-mill, acting only with its lateral pressure, it is natural to suppose its effects would be much greater if acting in a direct manner, so as to impel the sails forward in the same line of direction as the wind is moving. This, however, can only be accomplished by placing all the sails or vanes in a perpendicular manner, so as to receive its full and direct impulse upon each vane, in succession. To effect this, it is also necessary they should revolve in a horizontal direction. Many attempts, have at different times, been made to construct mills upon these principles; but the great difficulty has always been to make the sails return against the wind, without meeting with so much resistance as, in a great degree, to counteract, or at least very much to diminish, the power of the mill. Notwithstanding that difficulty, the advantages that would arise from such mills, have induced several very ingenious mechanics to turn their thoughts on finding out a proper mode of constructing them; and some have even taken out patents for them: but either from a defect in their principle, or from the great expence of executing them on the plans proposed, or perhaps from both causes, they have never yet been generally adopted. In some countries, however, horizontal wind-mills are the only mills in general use; particularly in Tartary, and some other parts of Asia; and Africa; and in several of the provinces in Spain. But in those countries, the only contrivance they have for preventing the resistance of the wind on the returning sails, is a sort of screen, which is moved round according to the direction of the wind, by which means, one side is always screened and sheltered from the wind, while the other is exposed to its full effect. But the machinery, and attendance requisite for turning or setting these screens according to the wind, and the other disadvantages attending them, must occasion a considerable deal of expence and inconvenience; neither can such screens prevent entirely the resistance of the air on the returning sails or vanes, which, even though completely screened and becalmed, must be considerable when in motion.

IV.

OBJECTIONS TO HORIZONTAL WIND-MILLS.

Making the Sails return against the Wind, the principal Objection—The late Mr. Smeaton's Opinion of Horizontal Wind-Mills—proved to be erroneous—Demonstration in different ways—may be made more powerful than the Vertical Mill.

A PRINCIPAL difficulty in constructing horizontal wind-mills, being to prevent the resistance of the wind on those sails or vanes that are returning against it, and at the same time to allow it to act with the best advantage on the other sails; if that difficulty can be overcome, and a mill constructed, upon one side of which the whole impulse of the wind may be received, while on the other it makes little or no resistance, a great point indeed would be gained, and the horizontal wind-mill would then answer every purpose expected from it. Some able mechanics have however, doubted if such a construction was practicable, thinking the difficulty of making the vanes or sails return back against the wind, could not be sufficiently obviated; but as many things that were formerly thought impracticable, have, of late years, been reduced to practice, by the great improvements that have been made in mechanics, it is the less surprising, that a difficulty of this nature should have come under that description, or that a mode should now be pointed out, in order to remove it. Even the late celebrated Mr. Smeaton says, that, " supposing each " vane of a horizontal mill, of the same dimen- " sions as each vane of the vertical, it is mani- " fest, the power of the vertical mill with four " sails, will be four times greater than the power " of the horizontal, let its number of vanes be

" what it will; and when we consider the further " disadvantage of *getting back the sails against the* " *wind*, &c. we need not wonder if this mill, in " reality, is found to have not above 1-8th, or " 1-10th, of the power of the common sort, as " has appeared in some attempts of this kind."

However presumptuous it may appear to dispute the authority, or to call in question the opinion of so eminent a mechanic and engineer as Mr. Smeaton was, yet, as the most celebrated artists may be liable to error, as well as the wisest and most able of other professions; I cannot help thinking, that in the above instance, Mr. Smeaton has very much deviated from that accuracy, and solidity of reasoning, which he has so clearly shewn on many other occasions. It is evident, in the first place, that he never had made any experiment at all upon a proper horizontal wind-mill; for by his mentioning the " difficulty of getting back the sails against the " wind," it is plain he never had a proper one to try any experiment upon. Had he ever tried any such experiments, he would, no doubt, have mentioned them. His ideas, therefore, concerning the power of a horizontal wind-mill, are merely conjectural, and founded on the imperfect constructions he had seen attempted.

In asserting, that the power of the vertical mill with four sails, will be four times greater than the power of the horizontal mill with sails of the same dimension, let their number be what it will; he seems in this case, for the sake of argument, to suppose all resistance against the returning sails out of the question; and to found his hypothesis upon the supposition, that in the vertical mill, the wind acts upon all the four sails at once, whereas in the horizontal, it can only act upon one at a time. Mr. Smeaton does not seem to allude to any particular construction of a horizontal mill, but rather appears to lay it down as a general axiom, that no horizontal wind-mill whatever can be constructed, but must fall under the disadvantages he mentions. In this, however, he is evidently mistaken. For admitting that the wind does act upon all the four sails of a common wind-mill, at once, and that it acts only upon one sail of a horizontal mill at a time; and supposing that the sails of a horizontal wind-mill are similar in size and shape to those of a vertical mill, only, instead of being placed in the common way, suppose them placed as in fig. I. AB and CD being horizontal arms fixed in an upright shaft EF; and the sail G fixed in a vertical position upon one of these arms, so as to receive the full and direct impulse of the wind; it is clear, that as the common wind-mill is moved only by the lateral pressure of the wind, the whole power acting upon all the sails together, is equal only to four times the lateral pressure acting upon each sail (supposing it to act upon each equally); consequently, according to Mr. Smeaton's mode of reasoning the power of a horizontal mill is equal only to one-fourth of the lateral pressure acting on a vertical mill; or in other words, he makes the lateral pressure equal to the direct pressure; which is contrary to every principle of mechanics: and it must be plain to every person, even to those who understand nothing of mechanical principles, that the wind acting in a direct manner upon a sail placed in the position shewn at E in the figure, and impelling it forward, must of course impel it in that direction with more power than in a transverse direction, as in the common wind-mill; and therefore, the power of the wind acting upon a sail placed in that manner, is as much more than the fourth part of the power of the common wind-mill, as the direct pressure exceeds the lateral pressure; consequently, a horizontal wind-mill, even on that rude and imperfect construction, with the wind acting only on one sail at a time, would evidently have, by its receiving the direct impulse of the wind, a proportionally greater power than what Mr. Smeaton seems to allow it to be capable of possessing; but it may still be made to have a great deal more power, even with the same sail. For suppose it placed, as shown in fig. II. at A, the extreme length of the arms from the vertical shaft B, or centre of motion; it will then have at least four times the power it had in the former position; and therefore, although the wind acts but on one sail at a time, it will in that position have more power (supposing no resistance on the opposite side) than a vertical mill with sails of equal dimensions; which it is presumed, is a clear refutation of what Mr. Smeaton says on that point concerning the power of horizontal mills; and at the same time a proof, that on proper principles horizontal wind-mills may be made, having more power than vertical mills, with the same quantity of sail, and an equal length of lever.

V.

ON GETTING BACK THE SAILS AGAINST THE WIND.

Mr. Smeaton estimates the disadvantage of getting back the Sails to take away more than half the Power of the Mill—proved in one case, to take away only 1-52*d Part, and that it may be made even less—that Disadvantage not equal to the Friction in the Common Wind-Mill.*

WITH respect to the difficulty Mr. Smeaton mentions, of getting back the sails against the wind, that no doubt is the principal objection against horizontal wind-mills; and perhaps those horizontal mills which Mr. Smeaton may have seen, or formed an idea of, have been of so imperfect a nature as to warrant him in considering the diminution of power, by the resistance of the returning sails, equal to what he estimates; that is, to a reduction of one half, or more than one half, the power of the mill; for if the power of the horizontal mill was, as Mr. Smeaton asserts, only one-fourth of the power of the vertical, even when making no allowance for the resistance of the returning sails, it is evident he considers that resistance as taking one half from the power of the horizontal mill, by saying, when that is allowed for, it is reduced to one-eighth the power of the common wind-mill. If reduced to one-tenth, he must consider that resistance as equal to more than half its power. But in this he is also greatly mistaken, as I shall endeavour to demonstrate; and I hope to make it appear that instead of the resistance of the returning sails being equal to one half, or more than one half, the power of the mill, it is possible to construct them in such a manner, that the resistance occasioned by those returning sails will not exceed one-fiftieth part of the power acting upon the mill, which is far less than the additional friction the vertical has more than the horizontal mill. To demonstrate this, suppose two equal square surfaces or frames, ABCD and DEFC, fig. III. each side being twelve feet in length; if these two frames are placed in a vertical manner, at right angles, or in direct opposition to the wind, and the frame ABCD is covered with canvas, or any other material to stop the current of the wind; if at the same time the other frame is quite open and uncovered, so that the wind will pass freely through, it is evident, that while the wind is acting with a power on ABCD equal to 144 times its pressure, on one square foot, it meets with no resistance at all on DEFC (for the sides of the frame are supposed excluded in both cases); but if across the frame DEFC a bar is fixed, as in fig. IV. at G, the wind will then meet with a resistance on that side, in proportion to the breadth of that bar; which, supposing it to be one inch broad, would be equal to its pressure upon one foot on the side ABCD; if two or three inches broad, the resistance would then be equal to the pressure on two or three square feet on ABCD; and therefore, whatever may be the breadth of that bar on that side of it opposed to the wind, or if there are more than one bar placed across DEFC, whatever may be the breadth of the whole added together, the resistance made will be in proportion to their surfaces collectively opposed to the wind. Suppose therefore the square DEFC, fig. V. divided into twelve equal parts by parallel lines, at the distance of one foot from each other at their middles, there will then be eleven of those lines, which, if they are supposed to be a quarter of an inch each in thickness, will occupy $2\frac{3}{4}$ inches in breadth, by twelve feet in length of the surface, that is, two square feet and three quarters of a foot; but as the whole surface DEFC contains 144 square feet, if that is divided by 2¾, it will show that these lines occupy only a little more than a fifty-second part (52.36) of that whole surface; and therefore, if the square ABCD is covered with a canvas or sail containing 144 square feet, and the square DEFC is quite open or uncovered, excepting by the parallel lines of a quarter of an inch each in thickness, it is evident that if the wind is acting upon both of these square surfaces at the same time, it will meet with a resistance upon ABCD equal to 144 times its pressure upon one foot; whereas on DEFC, it will meet only with the resistance of the parallel lines, being equal to 2¾ times its pressure upon one foot, which is but a fifty-second part of the resistance on the square ABCD.

To illustrate this proposition still more clearly, suppose the pressure of the wind, in a moderate breeze, to be equal to two pounds weight upon every square foot, then upon the square ABCD there will be a pressure of 288 pounds, and on DEFC only five and a half pounds, which is a 52.36th part as before. This, however, is on the supposition, that these two square surfaces are immoveably fixed; but if the line DC is supposed to be an axis upon which they are moveable and can revolve, the effect will be very different; for in that case the sides DA and CB of the one square, and DE and CF of the other, will become levers acting upon the common fulcrum DC; and the effect of the power of the wind upon the square ABCD on the one side, and its resistance upon DEFC on the other, will increase upon every foot as it recedes from the fulcrum, or common centre of motion: that is, supposing DE and CA divided into twelve equal parts of one foot each, and joined by parallel lines drawn vertically between them; these parallel divisions will contain twelve square feet each; the power of which, in proportion as they recede from the centre of motion, will on the square ABCD be as follows:

On the first division from the centre		24 *lbs.*
On the second ditto	—	48
On the third ditto	—	72
On the fourth ditto	—	96
On the fifth ditto	—	120
On the sixth ditto	—	144
On the seventh ditto	—	168
On the eighth ditto	—	192
On the ninth ditto	—	216
On the tenth ditto	—	240
On the eleventh ditto	—	264
On the twelfth ditto at the extremity		288
	In all	1872 *lbs.*

By this calculation it appears that, when the wind acts with a power equal to two pounds weight on a superficial square foot at rest, the effect of that power on a surface twelve feet square, moving upon an axis as above described, will be equal to 1872 pounds weight; but from this is to be deducted the resistance on the opposite side, which will also increase in proportion as it recedes from the centre, in the following ratio:

Each foot in length from the centre, being 2¾ inches broad, the resistance wll be

On the first	—	7.33	ounces.
On the second	—	14.66	
On the third	—	21.99	
On the fourth	—	29.33	
On the fifth	—	36.66	
On the sixth	—	43.99	
On the seventh	—	51.33	
On the eighth	—	58.66	
On the ninth	—	65.99	
On the tenth	—	73.33	
On the eleventh	—	80.66	
On the twelfth	—	87.99	

In all 572.00 ounces, or thirty-five pounds twelves ounces, or about a fifty-second part of the power of ABCD, as before; being in decimals 52.36, precisely the same as in the former calculation on the two surfaces when fixed, which is a proof of the accuracy of both the theories. But although the proportional resistance is the same in both cases, yet the difference of power is very great; for in the first case, if the pressure of five and a half pounds on the one side is deducted from 288 pounds on the other, there remains a difference of only 282$\frac{1}{2}$; but in the latter case, if 35 pounds twelve ounces are deducted from 1872 pounds, there remains 1836 pounds four ounces, as the superiority of power that ABCD has more than DEFC when turning on the same axis.

It is therefore evident, that if a horizontal mill can be constructed on this principle, so that the whole power of the wind may act in a direct manner on the one side, while on the other, being the side returning against the wind, it meets only the resistance of a few parallel lines, in that case (and the sails or vanes being of the dimensions of the squares above mentioned), the returning sails, divided as in fig. V. will make a resistance only equal to a fifty-second part of the power acting upon the mill; whereas Mr. Smeaton supposed and asserted, " that in all " horizontal mills the resistance of the return-

" ing sails would be equal to more than one " half the power of the mill." Having now, I trust, clearly demonstrated that Mr. Smeaton's opinion concerning the power of horizontal wind-mills, is altogether erroneous and unfounded, and that instead of those mills having not above one-eighth or one-tenth of the power of common wind-mills, it is possible to construct them in such a manner, that even with the same quantity of sail they may be made more powerful than vertical mills, I shall now proceed to show how such mills may be constructed on the principles I have here laid down; but I shall previously make a few remarks on another argument that has sometimes been used against horizontal wind-mills.

VI.

ANOTHER OBJECTION TO HORIZONTAL WIND-MILLS ANSWERED.

Velocity of the common Wind-Mill sometimes greater than the Wind—this property not peculiar to the Vertical Wind-Mill—other Mills or Wheels may move with greater Velocity than the Power that moves them—exemplified—Horizontal Mills will do the same—demonstrated.

Those who have only been accustomed to vertical wind-mills, and who have never seen a proper horizontal one, argue in favour of the former, that they will sometimes revolve with greater velocity than even the wind itself; consequently that they must have more power than the horizontal mill, which, say they, cannot be made to move so fast as the wind. This is another proof how little the power and principles of the horizontal mill have hitherto been understood or attended to.

That the vertical mill will sometimes move with greater velocity than the wind, is not disputed; but that can only happen when the mill is going empty or unloaded, or at least when meeting with but little resistance;' nor can it ever be the case excepting at or near the outer extremities of the sails, or at a considerable distance from the centre of motion. At those parts the sails may often move with greater velocity than the wind, and it is most likely they generally do so, otherwise the mill must be going very slow indeed; that however can be no argument in favour of the superiority of the vertical mill, as it proves nothing more than what every other mill or wheel possesses in a similar manner, whether vertical or horizontal; for it may be demonstrated, that any such wheel may be made to move with more velocity than the power that moves it. Suppose, for example, a fly-wheel, thirty feet in diameter, turned by a handle placed eighteen inches from its centre; every revolution that handle makes round the axis of the wheel, it will describe an imaginary circle three feet in diameter, which is only one-tenth of the diameter of the wheel, any point in the circumference of which revolves in the same time, through ten times the space that the handle does; and therefore it moves ten times faster than the power that sets it in motion. If the handle or moving power were placed at three feet from the centre, the circumference of the wheel would move five times faster; and if placed at seven feet and a half (the double of which is equal to the radius, or semi-diameter of the wheel) it would then move at only twice the velocity of the acting power. So it may happen with a vertical or any other mill; for as the power of the wind acting upon the sail of a wind-mill increases upon every point of that sail, as it recedes from the centre, there must be a certain point or line (which I shall call the line of action) where the power acting at that part of the sail is sufficient to turn the mill; and if the remaining part of the sail between that line and the extremity of the arms is, for experiment, taken away, the mill will still continue to go round; if that line is supposed to be at one-fourth the length of the arm from the centre, and moving at only one half the velocity of the wind, that point of the arms at one half the distance from the centre will be moving with the same velocity as the wind, and the extremities will at the same time be moving with double that velocity: if the remaining part of the sail is supposed to be now added, the velocity will be increased; if it is doubled, then the fourth part from the centre will move with the same velocity as the wind, and the extremities will be moving with four times that velocity. It is therefore evident, that at whatever part of the sails of a vertical wind-mill the line of action may be, those parts between that line and the extremities will move progressively faster, in proportion as they recede from the centre. The same argument will hold as to horizontal wind-mills of a proper construction; for if a horizontal wind-mill is going empty or unloaded, as in the former case, and is so constructed that there is little or no resistance on the returning side, the wind will act in a direct manner upon every part of each vane, when at right angles to its line of direction; as in the former case, there will also be a certain line of action on the vane, at which the power acting is sufficient to turn the mill; the velocity of the different parts of the vane between that line and the extremities will likewise increase in proportion to their distance from the centre; whatever additional sail is put between that line of action and the extremities, will of course add to the power and to the velocity of the mill. Supposing, therefore, that part of the vane at one-fourth the distance from the centre is moving with a velocity equal to the wind, the part at half the distance to the extremities will be moving with twice the velocity, and the extremities at four times the velocity of the wind; that is, twice or four times its direct impulse: whereas in the vertical mills, in similar cases, it moves at the rate of only twice or four times its lateral impulse. This will perhaps be more clearly understood by the following statement:

In estimating the power of horizontal windmills, or rather in forming, as hitherto done, a superficial judgment of it (for I believe it is a subject that has never yet been sufficiently investigated), it should appear that the principal cause of the erroneous opinions that have been formed, has been by considering the effect of the wind on vanes, moving round upon a centre, the same as if it were acting on a plane surface set up in opposition to it; but the effect is widely different, as has already been proved in page 22, &c. When acting upon a plane surface of that description, at full liberty to be impelled forward by the wind, as on the sail of a boat, I admit that it is impossible for any such surface, however light, and however much at liberty it may be, to move with a velocity equal to the wind then moving it; but this case does not apply to the vanes of a horizontal windmill, moving round on a centre. For, let us suppose that, in fig. V. the vane or side

ABCD is divided as before mentioned into twelve divisions vertically, each division being one foot broad, and extending from the lower to the upper part of the vane; suppose also, that each of those divisions, or all of them, may be taken away separately; it is already shown, in the foregoing calculation, the effect of the power of the wind acting upon each foot as it recedes from the centre of motion; and also the resistance on each corresponding foot on the opposite side. If then, for example, the power of the wind, acting on the third division from the axis, is capable of turning round the vanes upon their centre of motion, and that all the other divisions are taken out of the frame, that division left, cannot move so fast as the wind, nor probably with more than half its velocity; suppose it half, then that part of the vane six feet distant from the centre of motion, will be moving with the same velocity as the wind; and the extremities twelve feet distant from the centre, will at the same time be moving with double the velocity of the wind. Again; suppose the first and second divisions now added, there will then be double the power acting upon the vane, which will double the velocity, and make the third division, instead of half the velocity, move with the same velocity as the wind; in which case the twelfth, or extreme division of the frame, will be moving with four times the velocity of the wind. Hence, it is evident that if the power of the wind acting upon the first, second, and third divisions, is sufficient to move the mill at this velocity, there will be none of its power at that time acting upon the remaining divisions, *when at right angles to the wind*, although all put in their proper places; but as the wind abates in its power, or as the resistance of the mill is increased, the line of action on the vanes will vary accordingly; and it will begin to act on the outward extremity whenever it passes the direct line towards the centre. This is perhaps a doctrine that has not before been sufficiently attended to, in considering the power capable of being given to a proper constructed horizontal windmill. If I have been explicit enough to make myself understood, it will plainly appear, by the foregoing calculations, that a proper horizontal wind-mill, in so far as the direct is more powerful than the lateral impulse of the wind, will have the advantage of the vertical mill, both in respect to its velocity and power. And when the great and principal difficulty is removed, of bringing back the sails or vanes, with the least possible resistance, against the wind, it will possess so many advantages over the vertical wind-mill, that no person, who has occasion for such mills, can hesitate a moment which to prefer. Even those who already have wind-mills of the common construction, ought to consider the great expence and trouble they are annually at in repairing those mills, and in attending upon them, to turn them according to every change of the wind; and how much it would be to their profit and interest, if, at a small expence, they can relieve themselves of these, and several other disadvantages, by changing their vertical, into a horizontal mill.

VII.

DESCRIPTION OF BEATSON'S ROYAL PATENT HORIZONTAL WIND-MILL.

Principles upon which that Mill is founded—Construction of the Parts forming the horizontal Movement—the upper and lower Arms—vertical Shaft—Vanes—Flaps—resisting and non-resisting Sides—Construction on a large Scale.

The general principle upon which this mill is founded, is that laid down in fig. III. IV. and

V. wherein it is shown, that if the wind acts with its full impulse on a covered surface, ABCD; and if, at the same time, it is allowed to pass through a similar space without any interruption, except by a few thin rods or bars placed across it, the power acting on the covered side will be as much greater than the resistance on the other, as the surface of that covered side exceeds the space occupied on the uncovered side by those rods or bars.

To apply this principle to practice, it is necessary that these surfaces should alternately change their power, but that the greater power should always be on one side. That is, when ABCD, fig. V. is turned round to the place occupied by DEFC, it must then lose all its power, and make no more resistance than DEFC did when in that position; and when DEFC is brought round to the place ABCD, it then receives the full power that ABCD had; by which alternate and successive change of power, a constant rotation is produced, that may be applied to give motion to any kind of machinery. The following is a description of the abovementioned mill, constructed on these principles:

Fig. VI. is a direct view or elevation of the opposite sides of the horizontal movement.

AB and CD, are two of the upper arms.

EF and GH, are two of the lower arms.

IK, is the vertical shaft into which these arms are fixed.

LMNO and PQRS, are two frames, which are either immoveably fixed between the upper and lower arms, or they are made to slide backwards and forwards, so as to be placed nearer to, or farther from, the vertical shaft. These frames are covered with any sort of thin light substance or material for the wind to act upon, as canvas, linen, silk, skin, or even paper or parchment; either of which may be prepared with oil, tar, varnish, or any other substance capable of resisting wet. It will, however, be observed, that with whatever material these parts (which are called the vanes) are covered, it must not be in one whole piece, but divided into several narrow parts or flaps. These flaps should consist of thin light frames for the covering to be stretched upon, and should be suspended upon gudgeons or hinges at the upper corners, so as to hang freely and loosely, and to be easily moved by the wind. They must also be so suspended as to overlap each other a little; that is, the lower part of the upper flap 1, must overlap the upper part of the flap 2; the lower part of 2, overlap the upper part of 3, &c. That side of the vane upon which they overlap, is called the resisting side; because, when the flaps are all suspended in this manner, and that side is turned to the wind, the whole flaps are shut, and resist the wind, the same as if the vane was covered with one entire piece. The other side is called the non-resisting side; because, when it is turned to the wind, the whole flaps will open, and allow the wind to pass freely through between them, with little or no resistance, except what is occasioned by their thin edges, which ought to be as thin as possible, that the resistance may be the less; for, if properly constructed and counterpoised (to prevent any resistance by their weight), that resistance will very nearly be as small as if there was no covering at all upon the vanes. Hence it is easy to conceive, that if LMNO is the resisting side, and PQRS the non-resisting side, and the full and direct power of the wind acting upon LMNO, while little or none of its power is acting on the side PQRS, the resisting side will, of course, be impelled forward according to the force of the wind; and, being succeeded by other vanes, a constant rotation will be produced. In fig. VII. is shown the position of the vanes with respect to each other, being a plan of four of them, A, B, C, and D, crossing at right angles. By this it is evident, that as the vane **A** is impelled forward, **C** advances and receives the impulse of the wind; and thus the one vane follows the other in constant succession, and by that means a horizontal rotative motion is produced, as before explained.

The power with which the wind acts upon these vanes, may easily be conceived by the force with which it sometimes acts even upon a small umbrella; which, small as it is, is often difficult to be managed in a strong breeze, even with its convex side to the wind: how much more powerfully, then, will the wind act upon vanes of the construction here described; more especially when the effect of that power may be increased, in proportion as the arms or levers are lengthened by moving the vanes farther from the vertical shaft, or centre of motion?

The vanes or flaps, instead of being covered with canvas, linen, or any such light material, might consist of thin light boards, or thin plates of iron, tin, or copper; in which case there will be no occasion for stretching frames to the flaps, as the gudgeons might be fixed to their upper corners.

If, however, they should be made of any of the latter materials, it will be particularly necessary to attend to their being properly counterpoised, in order to prevent any resistance their own weight might occasion.

When these mills are made on a large scale, it would be proper to divide the vanes vertically, into two or more pannels, as shown in fig. VIII. by which means the flaps will not have so great a bearing, and may, consequently, be made the lighter; and they might even be so contrived, that more or less vane may be given, according to the force of the wind, by drawing up all the flaps in any of the pannels required. Fig. IX. is a perspective view of one of these Patent Horizontal Mills at work, in a small building: the vanes are drawn out near the extremities of the arms. A, is the vane upon which the wind is acting with its full force; all the flaps being shut: B, has just passed the direct line of the wind, which still acts obliquely upon it: C, is the vane returning against the wind, having all its flaps quite open: and D, is just about presenting its edge to the wind, and the flaps are beginning to shut; immediately after which the wind begins to act upon it. The vanes, instead of being square, might be made of an oblong form, as fig. X. which, when extended to the extremities of the arms, will give a great power, with but a small proportion of sail or vane.

In large mills, too, it will be necessary to support the lower arms by struts or braces, as at AA; in fig. VIII. and there might be at the top of the vertical shaft, a rod or pole BC, from which may be fixed ropes CD and DE, to the extremities of the arms: or the part DE, instead of ropes, may be composed of small standards of wood, or iron if thought preferable. There might also be ropes fixed horizontally to the extremities of the arms; all which ropes and braces will tend very much to strengthen and keep the whole firm and steady. The above explanation being sufficient to show the principle of these mills, and the construction of the most material parts, it is the less necessary to enter into a description of the minuter parts, such as the manner of drawing out, or in, the vanes; of raising the flaps when required; and of regulating or stopping the mill (which may all be done from the inside); as these operations may be performed in various ways. At the same time it may be observed, that it is not requisite for all mills of this sort to be capable of these movements, as many of them may be made on a simple and cheap construction, with the vanes fixed; that might answer perfectly well for a great many useful purposes.

VIII.

ON THE POWER OF THE ROYAL PATENT HORIZONTAL WIND-MILL.

The Power acting on the one Side, great—the Resistance on the other, small—Calculation of the Power—Power may be increased by moving out the Vanes, or diminished by drawing them in—or by opening the Flaps in some of the Pannels of large Mills.

On viewing the figures, and considering the principle and construction of these mills, it will be evident, how great the power acting on the one side must be when all the flaps are shut, and a surface opposed to the wind the same as if it consisted of one entire piece; while, on the other side, by all the flaps being open, the wind will pass through between them, with very nearly as little resistance as if there was no covering at all upon that side. According to this construction, and to the principles already laid down, a pretty accurate estimate may be made of the power that may be given to these Patent Horizontal Mills.

Suppose, therefore, a mill on this principle, with vanes of the size before described, and that the wind is acting with a pressure of two pounds on a square foot at rest, it is required, what will be the power of such a mill,* each vane having twelve flaps, a quarter of an inch in thickness, on the upper edge? In a mill of this size, it would probably be necessary that the vanes should be divided in three pannels; in which case, there would be two upright standards or divisions in

---

* The velocity of the wind, and its perpendicular force upon a square foot, have been estimated as follows:

	lbs. avoird.	
1 Mile per hour -	.005	hardly perceptible.
2 Miles per hour -	.020	just perceptible.
3 ditto - -	.044	
4 ditto - -	.079	gentle pleasant wind.
5 ditto - -	.123	
10 ditto - -	.492	pleasant brisk gale.
15 ditto - -	1.107	
20 ditto - -	1.968	very brisk.
25 ditto - -	3.075	
30 ditto - -	4.429	high winds.
35 ditto - -	6.027	
40 ditto - -	7.873	very high.
45 ditto - -	9.963	
50 ditto - -	12.300	a storm or tempest.
60 ditto - -	17.715	a great storm.
80 ditto - -	31.490	a hurricane.
100 ditto - -	49.200	a violent hurricane.

each vane; but the pressure upon those on the one side, will be equal to the resistance of those upon the other; although a trifling advantage might be gained by making the standards, as well as the other parts of the framing, a little smaller; or of an angular form on the side that returns against the wind, and flat or hollow on the other. However, we shall consider them equal on both sides, and that the whole open surface, within the framing of the vanes (excepting the thickness of the flaps) is equal to twelve feet square, or 144 square feet; and that the vanes are close to the shaft, and only one acting, and another counteracting, at the same time. Upon these suppositions, the amount of the whole power pressing on the acting side of the vane, when at right angles to the wind, will be, as before stated, 1872 pounds; on the other side, there is the opposition of the edges of the twelve flaps (for, although divided by the upright standards, they may be considered as all in one length), being a quarter of an inch each; which added together, make a breadth of three inches: the resistance on each foot of which will be in the following ratio, as they recede from the centre of motion:

On the first	—	8 ounces.
On the second	—	16
On the third	—	24
On the fourth	—	32
On the fifth	—	40
On the sixth	—	48
On the seventh	—	56
On the eighth	—	64
On the ninth	—	72
On the tenth	—	80
On the eleventh	—	88
On the twelfth	—	96

Being 624 ounces, or 39 pounds; which is precisely $\frac{1}{48}$ part of the power acting upon the other side. Besides that resistance, some allowance must be made for the power requisite to raise up the flaps, which, when the mill is in motion, will be very small indeed; and if properly constructed and counterpoised, will not exceed half a pound, or at most one pound, for each flap. The deductions therefore to be made from the acting power will be

For the resistance of the edges of the flaps	39 lbs.
For raising the 12 flaps, suppose 1 lb. each	12
	51 lbs.

which being deducted from 1872, leave 1821 pounds as the effective power acting on the mill with that pressure of wind, no deduction being made for friction; but as this will depend entirely on the machinery annexed to the mill, and as it must evidently be a great deal less than the friction of the common wind-mill, we shall only at present consider its power, without making any allowance for friction. If, therefore, the power of a horse applied to machinery, is equal to 200 pounds, the acting power on a horizontal mill as above mentioned, would be equal to more than nine horses; which power, from the construction of the patent mill, might be greatly increased by drawing out the vanes: for if they were drawn out one breadth of themselves from the shaft, it would double the power of the mill, and make it then equal to eighteen horses, with only 24 feet of lever or arm; which is certainly more than could be accomplished with a vertical mill of the same length of arm, or even with arms of the usual length.*

It is presumed, therefore, that this mill possesses more power, than has ever before been attained by any other construction of a horizontal wind-mill; for although many contrivances have been proposed, and several different sorts of horizontal wind-mills have been made, yet, on comparing this construction with any other, it will at once be manifest, that none of them can, at so small an expence, and in so simple a manner, oppose so great a surface for the wind to act upon on the one side, and at the same time so proportionally small a one, and so little resistance, on the other. When it is also considered, the great power that may be given to these mills by the size of the vanes, and by moving them to the extremities of the arms, the saving of machinery, and other advantages, and likewise the facility of constructing them in almost any sort of building, or of applying them to buildings already constructed, even to dwelling houses or cottages, and that they may be made on a very small scale for many purposes, it is hoped they will prove a useful acquisition to the public; and that they will afford a much more simple and easy method of applying the power of wind to machinery, than any that has ever before been practiced.

---

* To avoid entering into a more minute calculation, the *ratio* between the power and effect; and the proportional resistance occasioned by the increased velocity of the returning side, are purposely omitted being noticed; but it is hoped the above statement will be sufficient to give a general

idea of the great power of these mills: their power with any other force of wind may be estimated according to the note in page 41.

IX.

ON THE USES TO WHICH THE PATENT HORIZONTAL WIND-MILL MAY BE APPLIED.

Grinding all sorts of Grain—Thrashing Mill—Chaff Cutter—Raising Water for all purposes—Manufactories, Distilleries, Breweries—Sugar Mills, &c.—exemplified in nineteen different ways.

ALTHOUGH these patent horizontal wind-mills may be used for every purpose that any other mill can be applied to, and may even be made to assist some other mills and engines, yet it may not be improper here, to enumerate the following uses to which they may, with great advantage, be applied:

1st. For grinding wheat or corn of all sorts, not only on an extensive scale, but even in small quantities for private families; it being in the power of most families to have a small horizontal wind-mill for that purpose. They would also be very useful for parish mills, to grind for the poor, or others.

2d. For grinding or bruising malt.

3d. For making pot or pearl barley.

4th. For splitting peas.

5th. For bruising corn for horses or other purposes.

6th. For cutting straw or chaff.

7th. For thrashing corn; for which purpose they might be extremely useful in almost any farm, as they might be erected in any barn, and would save entirely the expence of a horse-machine, and the building to cover it; or they might even be annexed to a horse-machine; and the one would greatly aid the other at any pressing time, in case there should be little or no wind.

8th. For raising water in a great variety of ways, and for many useful purposes; particularly for draining wet or marshy lands; for supplying towns or private houses, brewhouses, distilleries, and all manufactories, and other buildings or places requiring a constant supply of water. For drawing water from mines, quarries, or wells, or raising it to supply ponds, reservoirs, or cisterns of all sorts; or to supply water meadows or pasture fields; for which latter purpose, as well as for raising water out of wells, it would greatly ameliorate and soften the water, to keep constantly raising it by the mill to a certain height, in a small stream, and allow it to fall down again either from a cistern above, or otherwise: and, in short, for working pumps, or raising water for any sort of purpose. It might even be used on board of ship, on some emergencies; which would greatly assist and relieve the crew, especially in a leaky ship in a gale of wind; for which purpose a small horizontal mill, ready to put together, and to be fixed up when occasion may require, might be extremely proper on board of every ship going a long voyage.

9th. For turning the auger for boring, either to try for metals, minerals, coal, water, &c.; or for draining, according to the new system.

10th. For boring rocks to blast them: and it is presumed, it might even be used for boring rocks under water, either for the purpose of blasting them, in order to clear the entrance of harbours, rivers, &c.; or to fix any thing in them for any particular purpose.

11th. For spinning cotton, flax, hemp, wool, &c.; and might be of considerable use in making ropes of all sorts, or cables.

12th. For all sorts of mills or machinery used in bleaching, or in manufacturing cloths, linens, silks, &c. and for flax mills.

13th. For forges, foundries, and all sorts of machinery used in the manufacturing of iron or other metals, and of the various articles made thereof.

14th. For saw-mills for sawing timber, which would be particularly useful to all carpenters, joiners, and others who work in timber or wood of all denominations.

15th. For sawing marble or stone of any sort.

16th. For churning mills in dairies.

17th. For working the pile-engine for driving piles.

18th. For sugar mills and other machinery, used in the West India plantations. For which purpose they would be particularly advantageous, as the horizontal motion, adapted to the rollers or cylinders of the sugar-mill, is obtained at once, without the necessity of so much machinery as is used in other wind-mills, whereby a great deal of expence and labour will be saved; and as there will be much less friction, the mill will continue much longer in good order. Neither will they be liable to the damage frequently done by sudden squalls of wind, or by the wind changing suddenly, which sometimes carries away the sails and arms of the common wind-mill, before there is time to turn them properly to the wind. But as these horizontal mills will go with the wind from any quarter, and may be regulated from the inside, no such accident can happen with them. They might even be made to go by cattle or horses upon the same shaft, if thought requisite, in case of there being sometimes too little wind for them, although it is presumed, that when properly constructed, and in good order, they will go with less wind than the common wind-mill. Another great advantage of these mills, in respect to sugar-mills, is, that they may be constructed in any most convenient part of the buildings, so that there will be no occasion to have the mill detached from the other works, as is necessary with the common mill, which is frequently attended with many inconveniences, and even losses, when the spouts or troughs that convey the juice of the sugar-cane from the mill to the boiling house is not in the most perfect good order.

19th. For assisting water-mills or steam-engines: for which purposes they might, in many places be extremely useful in saving water to the former, and fuel to the latter.

It is unnecessary to enumerate any further uses to which this horizontal mill may be applied, as it may be used for every purpose that mills are generally applied to; and it may be applied to several, perhaps, that mills were never thought of being applied to before *.

---

* However ludicrous it may at present appear to perform such things with the wind, it is even possible to apply these mills to a machine for reaping corn, or mowing hay; for

X.

ADVANTAGES OF THE PATENT HORIZONTAL WIND-MILL.

Little Expence—no Attendance to turn them to the Wind—will go with any Wind—constructed in any form of Building—easily regulated or stopped—little Friction, and easily kept in Repair.

I SHALL now conclude the account of this mill with a short statement of some of the advantages resulting from it; which advantages are chiefly as follow: viz.

That it does not require any of those wheels, or other expensive machinery, near the top of common wind-mills, nor any of the apparatus on the outside below, for turning it round; and may therefore be constructed and kept up at less expence.

That it will go from whatever quarter the

---

breaking stones for roads; for cutting channels for small drains; or even ploughing in bogs and mosses, that are too soft to bear cattle; for moving carrriages upon ice, or smooth level roads open to the wind; and perhaps for several other purposes not yet thought of.

wind blows, and turn always the same way; and therefore does not require any attendance to turn it to the wind.

That it may be constructed in buildings of any form, or in buildings already erected, and does not require being detached from other buildings, as the common wind-mill does.

That being applicable to any sort of building, and capable of being constructed on any scale, these mills may be used much more generally than other wind-mills, in manufactories of all sorts, in farm buildings for grinding or thrashing corn, raising water, &c.

That it will admit of a great deal more accommodation than is possible to be obtained in common wind-mills; at the same time the building may be less expensive.

That it may be regulated or stopped with the greatest ease, even from the inside of the mill, or it may be made to regulate itself.

That there is no danger, as in the common wind-mills, in furling and unfurling the sails, which is sometimes attended with fatal consequences.

That they may be kept in repair at less expence than other wind-mills, having much less machinery, and a great deal less friction.

XI.

APPLICATION OF THE SAME PRINCIPLE TO WATER-MILLS.

Horizontal Water-Wheel—Construction—turns always the same Way, whether the Current runs up or down—a more powerful Wheel of the same sort—Sluices to open and shut themselves—Uses of these Mills—Tide-Mills.

THE same principle upon which the horizontal wind-mill is founded may likewise be applied to the construction of horizontal water-mills, as follows:

Figures XI and XII. AB is the horizontal water-wheel placed in the current of a river, or of the tide: at which place it may be contracted by two walls, C and D, or by any other means, in order to render the current the stronger at the wheel, which may be put either under the arch of a bridge or in any other most suitable place. A is the side with the flaps shut, or the resisting side, when the current runs in the direction of the dart 1. B is the open or non-resisting side, advancing against the current. But when the stream runs in the direction of the dart 2, B will be shut, and become the resisting side, and A will be open, and be the non-resisting side. It is therefore evident that whatever way the stream runs, the wheel will always turn round in the direction of the four crooked darts, *dddd*; and if the overlaps were made on the side B, it would always turn the reverse way. The flaps for water-wheels of this sort might be made of thin boards, or of thin plates of iron, copper, or other metal, which perhaps would be the best, as being thinnest, and making least resistance. These water-wheels may be stopped or regulated by a sluice on either side to stop the current, or to admit only so much of it as is thought necessary; and there may also be sluices at C and D to open when the wheel-sluice is shut. If a more powerful mill of this kind is wanted, and that it might not be thought proper to admit a stream upon the wheel, the whole width of its diameter, it may be constructed as in fig. XIII. ABCD is a close hollow wheel, having four or more vanes, A, B, C, and D, projecting about three or four feet from its circumference. These vanes are divided into so many flaps, as in the other wheel, the resisting side being those on which the letters are placed. E, F, G, and H are four sluices. When the current runs as shown by dart 1, the sluices E and F are open, and G and H are shut; by which it is evident the whole force of the stream will in that case act upon the vane A, and so impel it forward, and it will be succeeded by D, &c. and produce a constant rotation. When the current runs as shown by the dart 2, the sluices G and H will open, and E and F shut; by which means it will act on the side C, and force the wheel round the same way as when it acted upon A; so that whichever way the current runs, the wheel will turn round always in one direction. The sluices may be made to open and shut themselves, and on the same principle as the vanes of the wheel, as will afterwards be explained when describing its application to sluices. It will probably be supposed that a wheel with sluices on this construction may be made to go round, although the vanes are not divided into flaps; and there is no doubt but it may; but it cannot be so powerful, as the resistance will be so great when returning on that side where the current is stopped, that they will with difficulty force their way through the water; whereas, by being divided into flaps, and these flaps being always open, except on the side upon which the stream is acting, they will the more easily get through, and those that are shut will act the more forcibly.

The principal uses of these horizontal water-mills will be in rivers that sometimes rise or fall much, and where undershot or overshot wheels cannot conveniently be placed, for they will go either wholly under water, or partly so. They might also be useful in rivers where the tide flows, or for tide-mills in many situations.

XII.

APPLICATION OF THE SAME PRINCIPLE TO OTHER PURPOSES.

Square-Pumps—their Construction—Flap Piston—Flap Valve—their Uses on board of Ship in case of a Leak, or Fire—to empty Ditches—Ponds, &c.—Sluices—moving Boats or Vessels—Accelerators—Methods of working them—Conclusion.

There are various other purposes to which the same principle may be applied with considerable advantage. Pumps on a large scale may be constructed in the following manner, and so contrived as easily to be taken to pieces, and carried from one place to another. These pumps should be made of a square form, and may be of any size, according to the quantity of water intended to be raised, and to the power that can be applied to raise it to the height wanted. Fig. XIV. is a pump of this nature. It consists of four sides of strong well seasoned board or plank, closely jointed. These sides may be held together by iron hoops, or by screws and bolts, so that they may be taken asunder when required, in order, if thought necessary, to pack in the smaller compass when carried from one place to another. Fig. XV. is the piston rod with the piston, which is one part to which the principle of the patent mills is applied, being divided into a number of small flaps, that open when the piston descends, and shut when it ascends, and raises the water. A is a small frame with similar flaps on the same principle, which may be called a flap valve, fixed in the tube of the pump, a little below the piston, in order to prevent the water raised by the stroke of the piston from returning back, when the piston is descending to take it up. The principal advantage of these square pumps is, that they may be made of a very large size at a small expence;

and the piston and valve being constructed with narrow flaps, they open easily, and shut instantaneously, without losing any advantage of the stroke, as would be the case in a common piston or valve of so large a size.

Having so wide a tube they will raise a great quantity of water every stroke, even though the stroke should be but short; and by making the lever of considerable length, a small power applied to it, will in a very short time raise a large quantity of water *. Such pumps might be extremely serviceable if kept on board of ship, ready to put together in cases of emergency. For if a ship sprung a leak, or if the other pumps should happen to be choaked, or unfit to keep her clear, pumps on this principle might be put down the hatchways, and would soon throw out an immense deal more water than is possible to do by bailing, or any other method; by which means the lives of many a brave seaman might

---

* It may sometimes happen that it would be much easier and more convenient to apply a short stroke than a long one; in which case these pumps would be very advantageous; for if only eighteen inches square, they would raise as much water with one six-inch stroke, as a pump six inches square (which is much larger than usual) would do at nine such strokes, or at 4½ twelve-inch strokes, or three strokes of eighteen inches.

often be preserved; when, without such a precaution, all their efforts would be in vain. Such pumps might even be so contrived as to put over the side of a ship in case of fire, in order to raise water to extinguish it. They might also be useful for emptying ditches, (particularly on the sides of roads) or ponds, or other places where it is not necessary to raise the water to a great height: and in some cases they might be worked by the horizontal wind-mill, already described.

In many situations sluices constructed on a similar principle might be useful; especially where they are required to open and shut of themselves, in order to allow the water to come in or to go out only in one way, as in the case of the horizontal water-mill, shewn in fig. XIII, where the sluices E and F might be made to open, and those at G and H to shut of themselves, when the current runs in the direction of the dart 1; and when it runs in the direction of the dart 2, G and H to open, and E and F to shut. But in such sluices, and indeed in general, when this principle is applied to any aquatic operation, it will be better, instead of making the flaps to overlap each other, as when applied to wind, to make them bevil on the upper and lower edges, so that the one may shut as close as possible upon the other.

The application of this principle to the moving of boats or vessels in calms or in smooth water, may be effected in different ways; a great deal of the power applied to the common oar is lost by the manner of applying it, as will easily be understood by every person who knows any thing of mechanical principles, when he considers that it is applied to the short arm of the lever, which in most oars does not exceed one-fourth its length; the other three-fourths from the fulcrum being without the side of the boat, consequently the rower labours to a great disadvantage; nevertheless these common oars are perhaps the best and most convenient sort that can be used for small boats of the common construction; but they cannot be used to advantage in vessels of any considerable size; and how very often does it happen that the people on board such vessels, when becalmed, or when anxious to weather or to approach any particular point or object, would give all they are possessed of for some assistance; how often does it happen too in time of war, that merchant ships might escape an enemy, or that ships of war or armed vessels might attack one, if they had some easy method of accelerating their motion? To point out the means of attaining this, is the object of what I am now about to describe, and to all seafaring people, merchants, and others, who have often great property at stake upon the seas, it is an object of very considerable importance; even in a national point of view, an effectual plan of this nature is an object highly deserving of attention, considering the very great advantages it would afford to all vessels possessing such means, either of attacking or escaping from an enemy, as they found it most adviseable. Several methods might be pointed out, of applying the principles already mentioned, towards moving boats or vessels; one method is explained by fig. XVI. which is a view of a machine something resembling the rudders used for flat bottomed vessels: the part A, instead of being constructed in the usual manner, is composed of several flaps that open and shut easily; these flaps should be made of thin boards, or thin sheet copper or iron, which may be painted or pitched to prevent corrosion. BC, is a post to which the framing the flaps are hung in must be well secured, which framing should present as narrow an edge as possible to the water. DD, are gudgeons in the post, for working into iron eye bands or staples, fixed in the side of the vessel. E, is a wooden handle or handspike, put into a mortise near the top of the post; the broad part A may be of any length or breadth, according to the size of the vessel; but when the gudgeons DD, are put in their proper places, the upper part at A should be nearly even with the surface of the water, or rather a little below it. There might be another gudgeon near the bottom of the post at C, if it would be of any use, which it perhaps would not be in vessels of the common form; but if applied to a flat bottomed vessel, with the sides nearly straight up and down, a gudgeon near the bottom of the post, would be very proper; but as most vessels have a considerable bulge on their sides, it might be adviseable in such vessels, to have a piece of strong plank, resembling fig. XVII. fitted to that bulge, (but moveable at pleasure) into which the iron rings or staples for the gudgeons might be fixed. The whole being put in its proper place over the side of the vessel, and the resisting side being towards the stern, it is evident, that by turning it on the gudgeons, the flaps will all open and make very little resistance when turned or drawn towards the bow of the vessel; but when drawn towards the stern, they will all shut and make a very considerable resistance, which will impel the vessel forwards.

If it is thought the handle E, does not give power enough, or that there would be any inconvenience by its making so great a sweep, there might be a rope fixed to the eye-bolt at F; one end of which is taken forwards, and the other aft, towards the stern. By pulling these ropes alternately, the vessel will be moved accordingly; that is, a man or boy, at the fore part, by pulling forwards; and two or three at the other end of the rope by pulling it backwards, towards the stern, will give motion to the vessel. The power of these machines, (which may be called *accelerators*) will of course depend entirely on the extent of their surfaces, especially on their length outwards; but it is at once evident, that they must have an infinite deal more power than is possible to give to an oar of the common construction: and, by applying three or four of them to each side of a vessel, it is easy to conceive, that when they are all acting, they will impel her forward with considerable velocity. If ropes are found more convenient for working the accelerators, than handles, the rope for drawing the flaps forward, (as it will not require much power to do so) may be fixed to the end of the handle, which in that case, may be a good deal shorter, and held by the same persons who draw it back, who in that way may perform both operations. In vessels that are not very high above the water, a better way than either of these for working the accelerators, would be by a long pole with a ring or staple at the end of it, to go upon an iron pin or bolt at F, instead of the eye-bolt there; by which pole the accelerator could both be drawn backwards and pushed forwards. By having two such poles connected together with a cross bar, an accelerator on each side of the vessel might both be worked at once. Fig. XVIII. is another method of constructing these accelerators, which, by extending the flaps to a farther distance from the side of the vessel, may give a good deal more power with only the same or even a less, acting surface; and on that account is perhaps preferable to the former method. It is unnecessary to pull them quite round when drawn forwards; but when drawn backwards, they should be hauled quite close to the side of the vessel, and let remain there for a little while before a new stroke is taken. It will be observed, that the manner they act is very much upon the same principle as the side fins of a fish, by which, although so small in proportion to the size of some fishes, they dart themselves forward with so much velocity. Fig.

XIX. is a plan of the upper part of a vessel, showing the position of three accelerators on each side, the two aftermost ones being drawn close to the sides, in the position they acquire after having completed the stroke. If vessels were built with a view of using such aids, they might be so constructed that the accelerators would lay quite flat to, and flush with the sides, and would be very little in the way although allowed to remain constantly there. Several other ways might be mentioned of constructing and working these machines, or others on the same principle. One of a larger size might be suspended by the middle over the stern, and pushed backwards and forwards from the stern ports of a large vessel, or even from the quarter-deck of most ships. Small machines of a similar kind, about three or four feet square, might be fixed to the end of long poles, as shown in fig. XX. so that they would resist when pushing away, and by the flaps all opening would easily be drawn back; such as these might be useful, not only for giving motion to the vessel, but would be particularly so to prevent her missing stays, as many vessels are sometimes apt to do. They might even assist in keeping her to windward. Whatever method may be adopted for giving motion to vessels, it may sometimes happen, that the horizontal wind-mill might be very advantageously applied to work any such contrivances; but to enter into a description of the manner of applying it, and of the different methods that might be used for that purpose, would far exceed the bounds intended for this Essay, and therefore having so fully explained the principle of these inventions, and the manner of applying it to several useful purposes, I presume it will easily be understood how to apply it to others of an inferior nature: such as ventilators, methods to prevent the back-draught in flues or vents, cases or boxes for chimney tops; a method of increasing the motion of swimmers, &c. to all of which the same principle may on many occasions be applied with advantage.

THE END.

BRITISH LIBRARY

Fig. 9

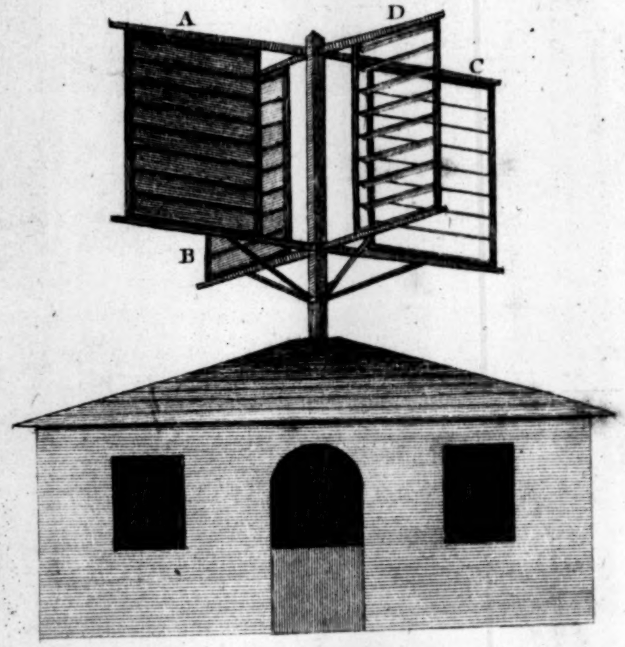


Fig. 10

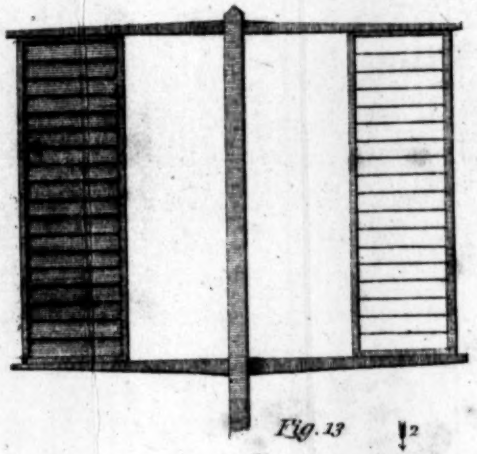


Fig. 11

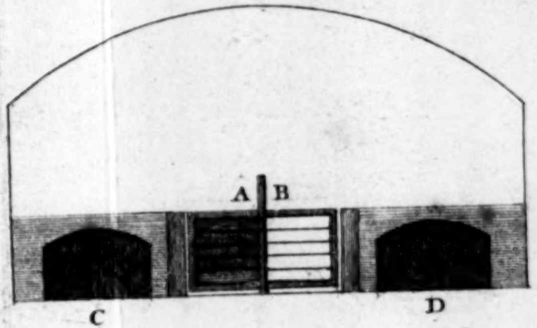


Fig. 13

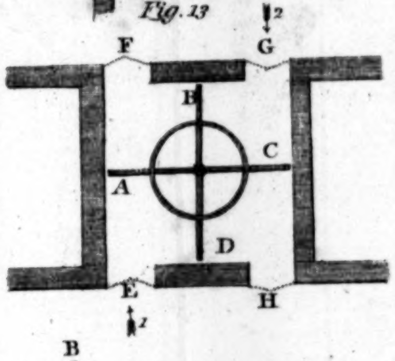


Fig. 12

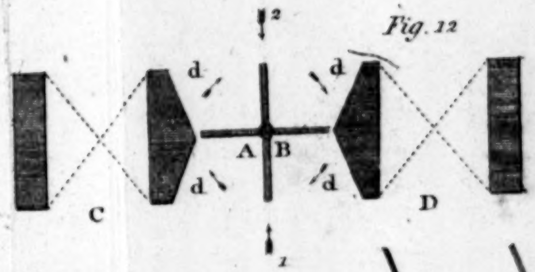


Fig. 14

Fig. 15

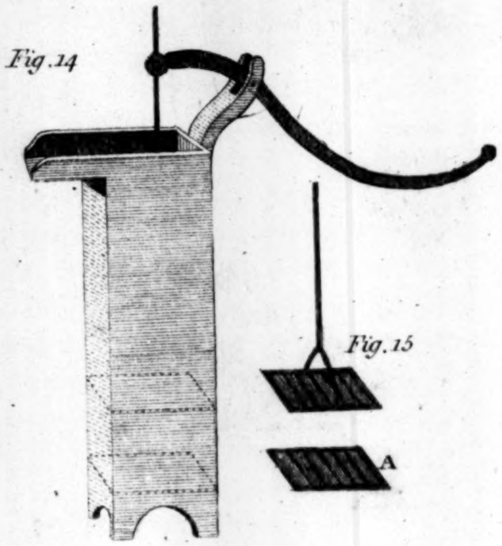


Fig. 16

Fig. 17

Fig. 18

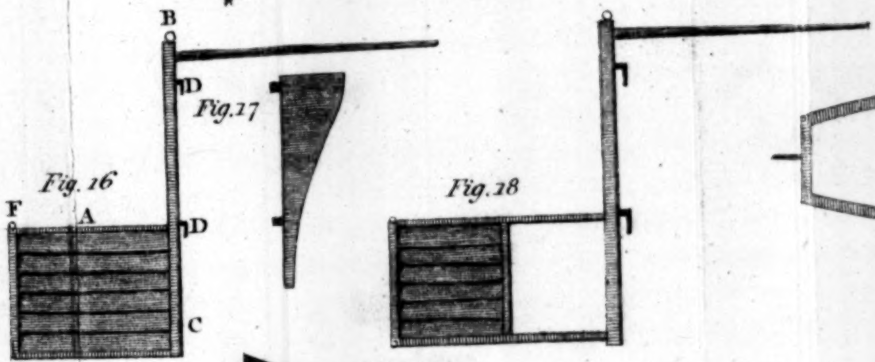
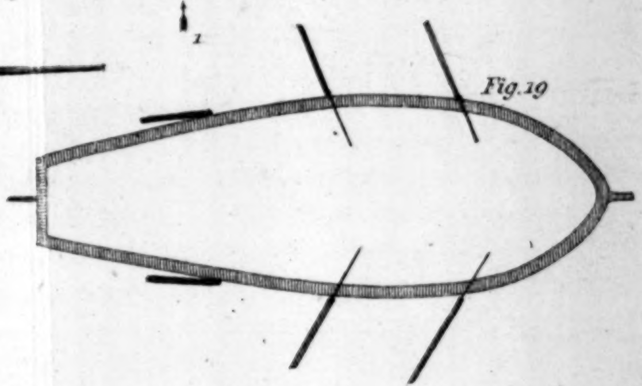


Fig. 19



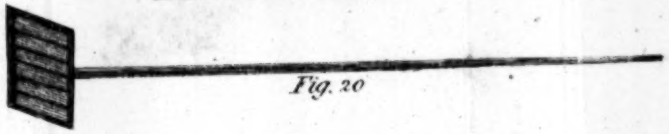


Fig. 20

Beatson del.t

Neele sc. Strand.

67

Plate I

Fig. 1.

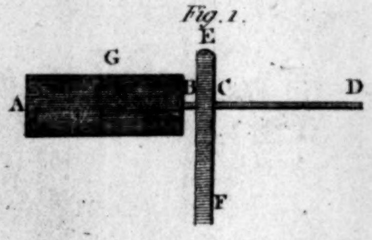


Fig. 2.

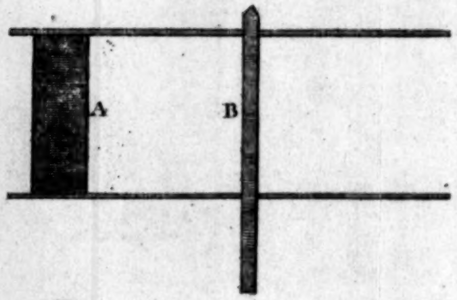


Fig. 3.

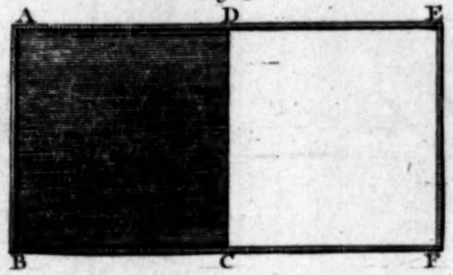


Fig. 4.

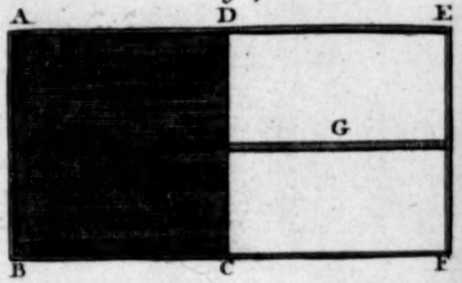


Fig. 5.

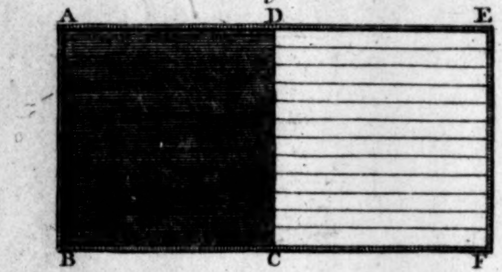


Fig. 6.

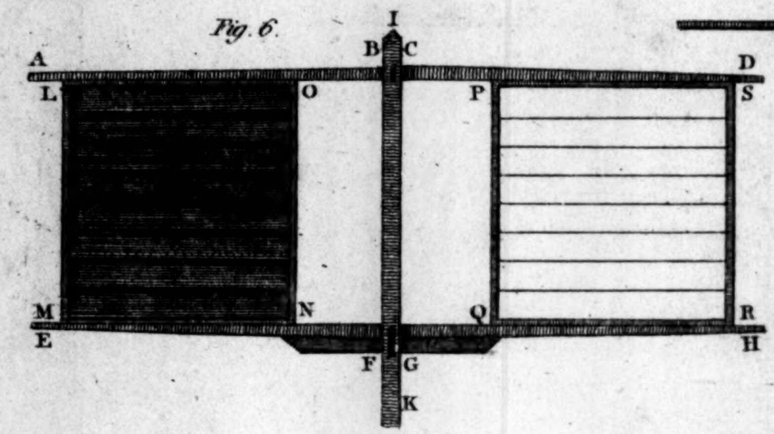


Fig. 7.

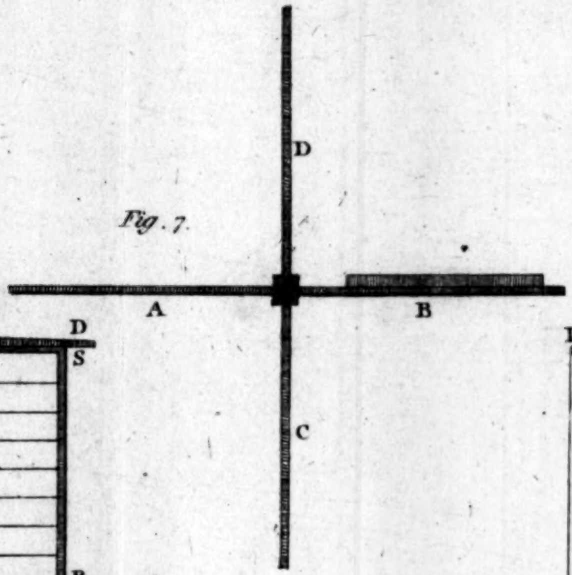
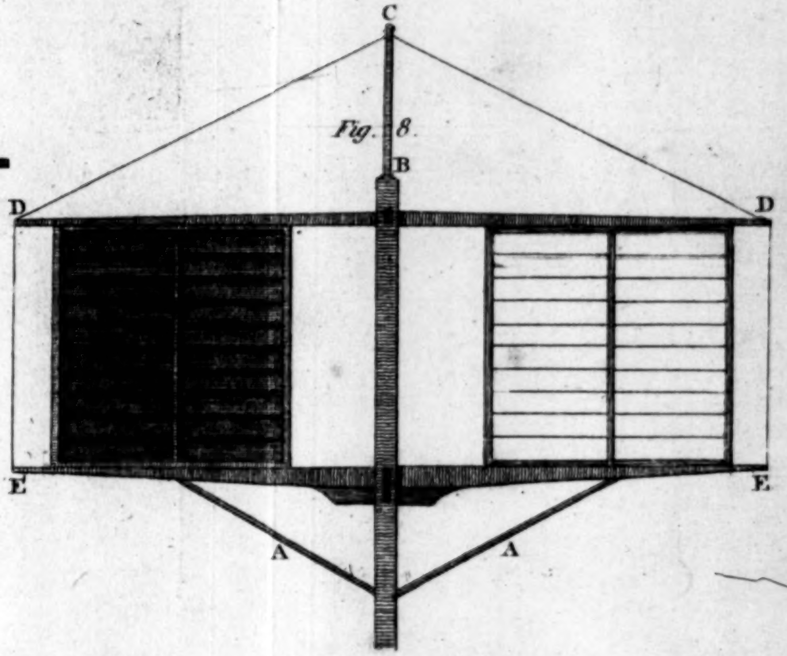


Fig. 8.



R. Beatson del.

Neele sc. Strand.